Disclosure of Investment Information in Multiple Markets

Abstract

We study the effect of disclosure on firms' investment decisions when a firm competes with an identical competitor in (two) multiple markets and with limited investment resources. We focus on the case where the information disclosure environment may differ by each market. Consistent with previous research in a single Cournot competition, our results show that firms exert more aggressive investments under disclosure than under nondisclosure in symmetric disclosure environments. Our results also show, however, that firms exert less aggressive investments in a disclosure market than in a nondisclosure market if each market has an asymmetric disclosure environment. This stems from the fact that firms must concentrate their limited investment resources on a less competitive market, and multimarket contact allows firms to predict rival firm's competitive behavior.

Keywords: disclosure environment, multimarket contact, cost-reducing investment, Cournot competition

1. Introduction

This study examines the impact of information disclosure on firms' investment decisions when firms face competition from the same competitor in multiple markets. There are many studies addressing the impact of information disclosure on the product market. These studies suggest that information disclosure is an important factor in efficient capital markets while the disclosed information may be used by rival firms in competitive markets. For example, Bolton and Scharfstein (1990) analyze the situation in which disclosed information is used by investors to make investment decisions and is also observed by competitors. Graham, Harvey, and Rajgopal (2005) note that while managers want to improve their reputation through transparent reporting, they are concerned that proprietary information, such as business investments that represent the company's competitive advantage, may be used by competitors. This risk is one of the factors hindering voluntary disclosure.

In a Cournot competition, disclosing information on production capacity is considered to have a strategic effect and could cause a competitor's quantity to vary, which may be beneficial to a disclosing firm. Darrough (1993), for example, shows that for firms facing quantity competition, disclosure of low-cost information increases its expected profits. In a vertical structure where upstream companies sell products to downstream companies, Arya and Mittendorf (2011) clarify that the product quantity increases by disclosing low supply prices; that is, the production capacity of downstream companies increases. In this paper, we focus on cost-reducing investments to realize high productivity and examine how the disclosure of investment information affects firms' investment behavior.

Studies on the impact of cost-reducing investments in competitive markets include the following. Brander and Spencer (1983) show that firms that use R&D strategically, not just for cost reduction, cause an increase in investment and production. d'Aspremont and Jacquemin (1988), who focus on the spillover effect of cost-reducing investments and joint investments, show that investment has the strategic effect of changing the production quantity of competitors. Banerjee and Lin (2003) examine the effects of downstream firms' cost-reducing investment on upstream supply pricing. However, these results are based on competition in one market. When firms face competition in multiple markets, the impact of information disclosure on firm behavior may differ from the strategic effect in a single market.

In recent years, management diversification and internationalization have progressed, and there may be situations where the same competitors compete in multiple markets. Arya, Frimor, and Mittendorf (2010) analyze the disclosure policy of proprietary information from multiple segment firms. To prevent other companies from entering, firms do not disclose information on a specific segment but may disclose information in a firm that aggregates multiple segments. This is because disclosing the favorable news of one segment may assert the unfavorable news of other segments. Bose and Gupta (2016) analyze multi-market competition between chains versus independent stores and show that the chain store is less aggressive than the independent store. As noted in Darrough (1993, p. 556), "Action taken by the firm in one market might affect the equilibrium in the other market." In the situation where a firm faces competition in multiple markets, information disclosure does not necessarily increase firms' production and investment. Bulow, Geanakoplos, and Klemperer (1985) show that the behavior of firms in the first market can change the strategy of competitors in the second market by affecting their own marginal costs in the second market. Whether action in the first market will incur costs or benefits in the second market depends on the change in marginal costs in the second market and whether the competitors' products are strategic substitutes or strategic complements. Bernheim and Whinston (1990) examine how contact with multiple markets affects firms' cooperation in repeated competition and note that multimarket contact could weaken the competition. Thus, competitive relationships in multiple markets may be weakened by cooperation between companies.

As a study focusing on the level of information disclosure in a multimarket, Thomas and Willig (2006) show that if there is monitoring imperfection, the impact of adverse shocks in one market can be spread to other markets, and payoffs may be lower. On the other hand, Matsushima (2001) considers a situation where a company has a long-term strategic relationship. He shows that, when the competitor's strategy cannot be completely observed, multimarket contact improves efficiency and maintains the collusion of companies. To analyze the impact of information disclosure, we assume that two firms that compete in quantity markets in multiple markets invest to reduce costs. We focus on the case where the information disclosure environment differs depending on the market, not on information imperfection. We verify how the disclosure of investment information affects firms' investment levels, production quantities, and expected profits. As a result of the verification, we clarify that firms may increase their investment in the non-disclosure market rather than the disclosure market. This result contrast with the conventional wisdom obtained in a single Cournot market.

The remainder of this paper is organized as follows. Section 2 sets up the structure of product market competition and firm profits. In Section 3, the equilibrium is derived for each case: the disclosure case where all firms are required to disclose their investment information in both multiple markets, the non-disclosure case where there are no disclosure requirements in both markets, and the asymmetric case when only one market is required to disclose firms' investment information. In Section 4, we compare the results in all cases and evaluate the effects of investment information disclosure on firms' behavior in multiple markets. Our concluding remarks are presented in Section 5.

2. Model

Consider two independent markets, A and B, with two firms, 1 and 2, which are Cournot duopolists in both markets. Two competing firms produce a homogenous product in each market. Thus, the inverse demand functions for firm i ($i, j \in 1, 2, i \neq j$) in each market are represented as follows:

$$p_A = a - q_{Ai} - q_{Aj},$$
$$p_B = b - q_{Bi} - q_{Bj},$$

where a and b denote the demand intercept for the products, and, q_{Ai} and q_{Bi} denote the outputs of firm i in the markets A and B, respectively. Firm i can reduce its constant marginal costs c_{Ai} and c_{Bi} with investments e_{Ai} and e_{Bi}. Thus, the marginal costs for firm i are $C_{Ai} = c_{Ai} - e_{Ai}$ and $C_{Bi} = c_{Bi} - e_{Bi}$ in each market. To simplify, we assume that $c_{Ai} = c_{Bi} = c_{Aj} = c_{Bj} = c$ and $c < a, b$. Now, we can express firm i's profit as follows:

$$\pi_i = \left[a - q_{Ai} - q_{Aj} - [c - e_{Ai}]\right] q_{Ai} + \left[b - q_{Bi} - q_{Bj} - [c - e_{Bi}]\right] q_{Bi} - \phi_i(e_{Ai,}, e_{Bi}), \qquad (1)$$

where $\phi_i(e_{Ai,}, e_{Bi})$ is investment costs. We assume that $\phi_i(e_{Ai,}, e_{Bi}) = .5\theta_i^{-1}(e_{Ai} + e_{Bi})^2$ and parameter $\theta_i = \theta_j = \theta > 0$, which captures investment efficiency: the higher (lower) the θ, the lower (higher) the investment costs.[1] Again, the investment costs (i.e., the square of the sum of the two investments) represent that investments in both markets are substitutes: a high investment level in market $A(B)$ leads to a high investment cost in market $B(A)$. In some cases, the selection and concentration of investments may be required.

To focus on the investment information, we assume that all other components are common knowledge except the investment levels, which can be observed only if the disclosure regime in each market requires both firms to disclose investment information.

We posit a three-stage game. At Stage 0, we determine the disclosure regimes in market A and B, so firm i is required to either disclose its investment information in each market or not. At Stage 1, firm i chooses investment levels to reduce their marginal costs, e_{Ai} and e_{Bi}, in each market. Finally, firm i chooses output levels q_{Ai} and q_{Bi} in each market at Stage 2. Then, the profits for each firm are realized.

[1] To ensure that all values in our results are positive, we restrict the degree of investment efficiency. For details, see Section 3.3.

Stage 0⟶	⟶ Stage 1⟶	⟶ Stage 2
disclosure regime of each market is determined.	each firm chooses their investments levels in each market.	each firm chooses outputs levels in each market.

Table 1: Model Timeline

3. Analysis

We solve firm i's maximization problem through backward induction. At Stage 2, firm i chooses outputs levels of each market to maximize its profit, π_i. Differentiating Eq. (1) with respect to outputs q_{Ai} and q_{Bi}, we obtain the reaction functions as follows:

$$q_{Ai} = \frac{a - c + e_{Ai} - \hat{q}_{Aj}}{2}, \tag{2}$$

$$q_{Bi} = \frac{b - c + e_{Bi} - \hat{q}_{Bj}}{2}, \tag{3}$$

where $\hat{q}_{Aj}$ and $\hat{q}_{Bj}$ denote firm i's conjectures regarding firm j's outputs in market A and B, respectively. Firm i's conjectures will be consistent with firm j's outputs if firm j's investment information is observable; otherwise, firm i must guess j's outputs levels. We assume that both firms' conjectures are formed rationally and will be sustained in equilibrium without revising conjectures when the firms cannot directly observe the other firm's investment information.[2]

3.1. disclosure case

To investigate how disclosure regimes affect firms' investment and quantities decisions in multimarkets, we first study a disclosure case where firms are required to disclose their investment information in both markets A and B. In this case, firm i can use rival j's investment levels to determine its own outputs levels. Considering that rival j can also observe firm i's investment levels, we can replace $\hat{q}_{Aj}$ and $\hat{q}_{Bj}$ in Eqs. (2) and (3) with q_{Aj} and q_{Bj}. Now, we can obtain the equilibrium outputs levels at Stage 2 as follows:

$$q_{Ai}(e_{Ai}, e_{Aj}) = \frac{a - c}{3} + \frac{2e_{Ai} - e_{Aj}}{3}, \tag{4}$$

$$q_{Bi}(e_{Bi}, e_{Bj}) = \frac{b - c}{3} + \frac{2e_{Bi} - e_{Bj}}{3}. \tag{5}$$

Thus, we show that firm i's outputs increase with its own investments e_{Ai} and e_{Bi} but decrease with rival j's investments e_{Aj} and e_{Bj}. Each firm can alter its rival's output levels through investment.

[2] Rey and Vergé (2004) referred to this assumption as "passive beliefs," arguing that these beliefs present a natural restriction on potential equilibria. This assumption does not allow firms to revise their beliefs about rivals' information. Specifically, the authors show that passive beliefs in Cournot competition coincide with alternative beliefs, which allows firms to revise their beliefs about rivals' unobservable information.

Substituting Eqs. (4) and (5) into firm i's profit, we can represent firm i's maximization problem at Stage 1, as follows:

$$\max_{e_{Ai},e_{Bi}} \pi_i = \left[a - q_{Ai}(e_{Ai}, e_{Aj}) - q_{Aj}(e_{Aj}, e_{Ai}) - [c - e_{Ai}]\right] q_{Ai}(e_{Ai}, e_{Aj})$$
$$+ \left[b - q_{Bi}(e_{Bi}, e_{Bj}) - q_{Bj}(e_{Bj}, e_{Bi}) - [c - e_{Bi}]\right] q_{Bi}(e_{Bi}, e_{Bj}) - \frac{1}{2\theta}[e_{Ai} + e_{Bi}]^2. \tag{6}$$

This implies that firm i must consider the effects of investments e_{Ai} and e_{Bi} on rival j's outputs q_{Aj} and q_{Bj} as well as its own outputs q_{Ai} and q_{Bi}. Solving the above maximization problem, we can obtain the equilibrium investment levels, the equilibrium outputs levels, and the expected profits in a disclosure case. This leads to Proposition 1.

Proposition 1. *In the disclosure case, the equilibrium investment levels, the equilibrium outputs levels, and the expected profits for firm i are*

$$e_{Ai}^{DD} = \frac{9(b-a) + 4\theta(a-c)}{2(9-2\theta)},$$
$$e_{Bi}^{DD} = \frac{9(a-b) + 4\theta(b-c)}{2(9-2\theta)},$$
$$q_{Ai}^{DD} = q_{Bi}^{DD} = \frac{3(a+b-2c)}{2(9-2\theta)},$$
$$\pi_i^{DD} = \frac{(9-4\theta)(a+b-2c)^2}{2(9-2\theta)^2},$$

where the superscripts, "DD", denote disclosure regimes in each market; first for market A and second for market B, and D indicates that firms are required to disclose their investment information in the relevant market.

Proposition 1 shows that the equilibrium investment levels $e_{Ai}(e_{Bi})$ may decrease with the demand intercept $a(b)$ of its relevant market but increase with the demand intercept $b(a)$ of another market if investment efficiency is not considerably high (i.e., high investment costs). In a single Cournot duopoly market, we can expect that firms are willing to exert more investment to increase their own output and decrease their rival's output as market demand grows because firms' outputs are strategic substitutes, and the cost-reducing investment accelerates strategic substitutes. In multiple markets, however, substitutability of multiple investments requires firms to select and concentrate their limited investment resources in one of the markets. Suppose that market A's demand intercept, a, is high, firm i may expect that rival j chooses an aggressive investment level, e_{Aj}, in market A. The increase of rival j's investment in market A imposes two conflicting effects on firm i: (i) a decrease in investment, e_{Ai}, which has a negative effect for firm i in market A by decreasing its output, q_{Ai}. (ii) A reduction in investment cost for e_{Bi} has a positive effect on firm i in market B. The positive effect is greater than the negative effect only if investment efficiency is sufficiently low such as $0 < \theta < 9/4$.[3] In this sense, firm i is likely to concentrate its investment on market

[3]See the reaction function of investment at Stage 1, as follows:

$$e_{Ai} = \frac{4\theta(a-c) - 4\theta e_{Aj} - 9e_{Bi}}{9-8\theta}, \quad e_{Bi} = \frac{4\theta(b-c) - 4\theta e_{Bj} - 9e_{Ai}}{9-8\theta}$$

B to avoid competition in market A. Above equilibrium investment levels, $e_{Ai}(e_{Bi})$, however, positive values may not be maintained when the relevant market demand, $a(b)$, is substantially larger than the other market demand, $b(a)$, because firms must respond to its rival's excessive investment level in the relevant market. To focus on positive investment levels, we assume that the difference between demand intercepts, a and b, is sufficiently small.

On the other hand, the equilibrium investment levels, $e_{Ai}(e_{Bi})$, may increase with the relevant market demand intercept, $a(b)$, when investment efficiency is considerably high (i.e., low investment costs) such as $9/4 < \theta$. In this case, as market demand, a, increases, low investment costs allow firms to make a more aggressive investment on market A against their rivals because it is not necessary to select and concentrate their investment resources. The excessive increase in investment leads to intensive competition in market A but also imposes extremely high investment costs on market B as well as A. Thus, firms may not obtain a positive profit. Note that firm i's profit is yielded from $\pi_i = q_{Ai}^2 + q_{Bi}^2 - \phi_i(e_{Ai}, e_{Bi})$. Again, the second-order conditions for investments require us to restrict to $\theta < 9/8$. We focus on cases in which the positive investment levels and the second-order conditions are satisfied.

3.2. non-disclosure case

Next, we study a nondisclosure case where there are no disclosure regimes in both markets; that is, firms do not disclose their investment information and rivals' investment levels are unobservable in both markets. In this case, firm i must guess rival j's outputs to determine its own outputs levels, as follows:

$$\hat{q}_{Aj} = \frac{a - c + \hat{e}_{Aj} - \hat{q}_{Ai}}{2}, \tag{7}$$

$$\hat{q}_{Bj} = \frac{b - c + \hat{e}_{Bj} - \hat{q}_{Bi}}{2}, \tag{8}$$

where $\hat{e}_{Aj}$ and $\hat{e}_{Bj}$ are firm i's conjectures regarding rival j's investment levels. Again, firm i must guess rival j's conjectures $\hat{q}_{Ai}$ and $\hat{q}_{Bi}$ regarding outputs, q_{Ai} and q_{Bi}, as follows:

$$\hat{q}_{Ai} = \frac{a - c + \hat{e}_{Ai} - \hat{q}_{Aj}}{2}, \tag{9}$$

$$\hat{q}_{Bi} = \frac{b - c + \hat{e}_{Bi} - \hat{q}_{Bj}}{2}. \tag{10}$$

Solving with Eqs. (2) and (3) for reaction functions and the above conjectures simultaneously, we obtain the equilibrium output levels at Stage 2, as follows:

$$q_{Ai}(e_{Ai}) = \frac{a - c}{3} + \frac{3e_{Ai} - 2\hat{e}_{Aj} + \hat{e}_{Ai}}{6}, \tag{11}$$

$$q_{Bi}(e_{Bi}) = \frac{b - c}{3} + \frac{3e_{Bi} - 2\hat{e}_{Bj} + \hat{e}_{Bi}}{6}. \tag{12}$$

These show that the firm i's outputs respond only to its own investment, not rival j's actual investment.

Substituting Eqs. (11) and (12) into firm i's profit, we can represent firm i's maximization problem at Stage 1, as follows:

$$\max_{e_{Ai}, e_{Bi}} \pi_i = \left[a - q_{Ai}(e_{Ai}) - \hat{q}_{Aj} - [c - e_{Ai}]\right] q_{Ai}(e_{Ai}) \\ + \left[b - q_{Bi}(e_{Bi}) - \hat{q}_{Bj} - [c - e_{Bi}]\right] q_{Bi}(e_{Bi}) - \frac{1}{2\theta}[e_{Ai} + e_{Bi}]^2. \tag{13}$$

This implies that firm i does not consider the effects of investments, e_{Ai} and e_{Bi}, on its rival's outputs, q_{Aj} and q_{Bj}. Differentiating the above maximization problem with respect to e_{Ai} and e_{Bi}, and using the assumption that all conjectures are formed rationally and will be sustained in equilibrium, we can obtain the equilibrium investment levels, the equilibrium outputs levels, and the expected profits in a nondisclosure case. This leads to Proposition 2.

Proposition 2. *In the non-disclosure case, the equilibrium investment levels, the equilibrium outputs levels, and the expected profits for firm i are*

$$\begin{aligned} e_{Ai}^{NN} &= \frac{3(b-a) + \theta(a-c)}{6-\theta}, \\ e_{Bi}^{NN} &= \frac{3(a-b) + \theta(b-c)}{6-\theta}, \\ q_{Ai}^{NN} &= q_{Bi}^{NN} = \frac{a+b-2c}{6-\theta}, \\ \pi_i^{NN} &= \frac{(4-\theta)(a+b-2c)^2}{2(6-\theta)^2}, \end{aligned}$$

where N indicates that firms' investment information is not disclosed in the relevant market.

As in Proposition 1, the investment level in each market decreases with the demand intercept of its own market but increases with that of another market if investment efficiency is not considerably high (i.e., $0 < \theta < 9/8$). This stems from the belief that rival j is likely to choose an aggressive investment level, e_{Aj}, in market A and a low investment level, e_{Bj}, in market B if market A's demand intercept, a, is high. In such case, firm i is willing to concentrate a high level of investment in market B to avoid competition in market A even if firm i cannot observe rival j's investment levels.

3.3. asymmetric case

Finally, we study an asymmetric case in which market A requires firms to disclose their investment information while market B has no claim on disclosure. In this case, observable investment levels in market A allow firms to replace $\hat{q}_{Ai} = q_{Ai}$ and $\hat{q}_{Bi} = q_{Bi}$, whereas firm i must guess rival j's output, q_{Bj}, to determine its output level, q_{Bi}, in market B. Given this, we find that the equilibrium output levels, q_{Ai} and q_{Bi}, are consistent with Eq. (4) in the disclosure case and Eq. (12) in the nondisclosure case at Stage 2, respectively.

Substituting Eqs. (4) and (12) into firm i's profit, we can represent firm i's maximization problem at Stage 1, as follows:

$$\max_{e_{Ai},e_{Bi}} \pi_i = \left[a - q_{Ai}(e_{Ai}, e_{Aj}) - q_{Aj}(e_{Aj}, e_{Ai}) - [c - e_{Ai}]\right] q_{Ai}(e_{Ai}, e_{Aj})$$
$$+ \left[b - q_{Bi}(e_{Bi}) - \hat{q}_{Bj} - [c - e_{Bi}]\right] q_{Bi}(e_{Bi}) - \frac{1}{2\theta}[e_{Ai} + e_{Bi}]^2. \tag{14}$$

This implies that firm i considers the effects of investment on rival j's output only in market A in which there is a requirement to disclose. Differentiating the above maximization problem with respect to e_{Ai} and e_{Bi}, and using the assumption that all conjectures are formed rationally and will be sustained in equilibrium, we can obtain the equilibrium investment levels, the equilibrium outputs levels, and the expected profit in an asymmetric case. This leads to Proposition 3.

Proposition 3. *In the asymmetric case, the equilibrium investment levels, the equilibrium outputs levels, and the expected profit for firm i are*

$$\begin{aligned}
e_{Ai}^{DN} &= \frac{3(3b - 4a + c) + 4\theta(a - c)}{21 - 4\theta}, \\
e_{Bi}^{DN} &= \frac{3(4a - 3b - c) + 4\theta(b - c)}{21 - 4\theta}, \\
q_{Ai}^{DN} &= \frac{3(a + b - 2c)}{21 - 4\theta}, \\
q_{Bi}^{DN} &= \frac{4(a + b - 2c)}{21 - 4\theta}, \\
\pi_i^{DN} &= \frac{(4 - \theta)(a + b - 2c)^2}{2(6 - \theta)^2},
\end{aligned}$$

where the superscripts "DN" denote disclosure regimes in each market; that is, firms are required to disclose only in market A.

Note that results e_{Bi}^{DN} and q_{Bi}^{DN} in the nondisclosure market can be replaced with e_{Ai}^{ND} and q_{Ai}^{ND} in an asymmetric case when only market B requires disclosure. Proposition 3 also shows that the investment levels in each market decrease with the demand intercept of its own market but increases with the demand intercept of another market in the range of $0 < \theta < 9/8$. This implies that firms are likely to avoid market competition in any case of multimarket contact regardless of whether a rival's investment information is observable.

Again, our results indicate that equilibrium investment levels may be negative values when investment efficiency is not considerably low. Suppose that θ is extremely low such as $\theta \to 0$. In this case, firms are not likely to choose positive investment levels because the investment costs are extremely high. Firm i does not respond to rival j's investment levels when choosing its investment levels because the expectation is that rival j cannot maintain the investment at a positive level. Thus, firm i considers only the effect on investment cost for another market. This leads firms to choose negative investment levels if possible. To focus on positive investment levels, we assume that investment efficiency is not considerably high or low so that the following condition is satisfied:

$$\frac{12a - 9b - 3c}{4(a - c)} < \theta < \frac{9}{8}.$$

Now, we can compare all possible firm investment levels, output levels, and profits in multimarkets.

4. Results

In this section, we evaluate the effects of investment information disclosure in multimarkets. Considering our assumption concerning the difference between demand intercepts, a and b, and investment efficiency, θ, we can compare the investment levels, output levels, and expected profits of each case in Section 3. This leads to Corollary 1.

Corollary 1. *In multimarkets,*

(i). Investment levels and output levels are

$$e_{Ai}^{DN}\left(e_{Bi}^{ND}\right) \leq e_{Ai}^{NN}\left(e_{Bi}^{NN}\right) \leq e_{Ai}^{DD}\left(e_{Bi}^{DD}\right) \leq e_{Ai}^{ND}\left(e_{Bi}^{DN}\right),$$
$$q_{Ai}^{DN}\left(q_{Bi}^{ND}\right) \leq q_{Ai}^{NN}\left(q_{Bi}^{NN}\right) \leq q_{Ai}^{DD}\left(q_{Bi}^{DD}\right) \leq q_{Ai}^{ND}\left(q_{Bi}^{DN}\right).$$

(ii). Expected profits are

$$\pi_i^{DD} \leq \pi_i^{DN} \leq \pi_i^{NN}.$$

We find that investment levels are higher when both markets require disclosure than when both markets have no regimes (i.e., $e_{Ai}^{NN} \leq e_{Ai}^{DD}$ and $e_{Bi}^{NN} \leq e_{Bi}^{DD}$). This leads to an increase in output levels (i.e., $q_{Ai}^{NN} \leq q_{Ai}^{DD}$ and $q_{Bi}^{NN} \leq q_{Bi}^{DD}$). As previous research shows, in a single Cournot duopoly market, competing firms are willing to choose greater output levels as strategic substitutes, and disclosing private cost information has a strategic effect that shifts a rival's output.[4] As stated before, in our model, disclosure allows cost-reducing investment to reduce a rival's output in addition to increasing a firm's own output in each relevant market. Therefore, firms choose higher investment levels when both markets require disclosure. This leads to greater output levels but higher investment costs. Furthermore, substitutability of multiple investment exacerbates investment costs. Consequently, firms obtain less profit in both disclosure markets than in both nondisclosure markets (i.e., $\pi_i^{DD} \leq \pi_i^{NN}$). This leads to Proposition 4.

Proposition 4. *Firms choose higher investment levels when both markets require disclosure of firms' investment information than when both markets have no disclosure regime.*

[4] See Darrough (1993) and Hughes and Williams (2008).

In contrast to previous research, however, our results provide two interesting insights. First, our findings indicate that firms choose lower investment levels in a disclosure market than in a nondisclosure market (i.e., $e_{Ai}^{DN} \leq e_{Ai}^{NN}$ or $e_{Bi}^{ND} \leq e_{Bi}^{NN}$) if the other market is under nondisclosure. This stems from multimarket contact and investments substitutability. Note that firms must reduce their investment in one market to concentrate on the other market. Suppose that only market A requires firms to disclose investment information in our asymmetric case. It is expected that rival firm j chooses a lower investment level in nondisclosure market B to choose a higher level in disclosure market A. In this case, firm i is likely to reduce its investment in disclosure market A to concentrate on nondisclosure market B (i.e., $e_{Ai}^{DN} \leq e_{Ai}^{NN} = e_{Bi}^{NN} \leq e_{Bi}^{DN}$) because more profit is expected in a less competitive market B where rivals have low investment levels. This leads to a decrease in output in market A and an increase in output in market B (i.e., $q_{Ai}^{DN} \leq q_{Ai}^{NN} = q_{Bi}^{NN} \leq q_{Bi}^{DN}$). However, firms obtain less profit in an asymmetric case than in a symmetric nondisclosure case (i.e., $\pi_i^{DN} \leq \pi_i^{NN}$) because intensive competition in nondisclosure market B exacerbates investment costs. Second, investment levels in a nondisclosure market are higher than in a disclosure market (i.e., $e_{Ai}^{DD} \leq e_{Ai}^{ND}$ or $e_{Bi}^{DD} \leq e_{Bi}^{DN}$). Similarly, it is expected that a rival firm j chooses a lower investment level in nondisclosure market B than in disclosure market A if only market A is required to disclose firms' information. Therefore, firm i is likely to raise its investment on a nondisclosure market B and avoid a more competitive (disclosure) market A (i.e., $e_{Ai}^{DN} \leq e_{Ai}^{DD} = e_{Bi}^{DD} \leq e_{Bi}^{DN}$). This leads to a decrease in output in market A and an increase in output in market B (i.e., $q_{Ai}^{DN} \leq q_{Ai}^{DD} = q_{Bi}^{DD} \leq q_{Bi}^{DN}$). Consequently, firms obtain more profit in an asymmetric case than in a symmetric disclosure case (i.e., $\pi_i^{DD} \leq \pi_i^{DN}$) because less intensive competition in disclosure market B diminishes investment costs. These results lead to Proposition 5.

Proposition 5. *Multimarket contact encourages firms to choose higher investment levels in a nondisclosure market than in a disclosure market when the investment resources are restricted.*

In multiple markets, investments substitutability makes firms select and concentrate their limited resources on one market. Multimarket contact allows firms to predict rival firm's behavior in Cournot competition although this leads to unpredicted consequences for firms. Our results imply that firms are likely to compete in an invisible market compared with a visible market to avoid a more competitive market and to concentrate resources in a less competitive market.

5. Concluding Remarks

We examined the effect of disclosure on firms' investment decisions when firms compete with an identical competitor in multiple markets and with limited investment resources. We showed that firms exert more investments in both symmetric disclosure markets than in both symmetric nondisclosure markets. However, our results also showed that firms exert less investments in a disclosure market than in a nondisclosure market if each market has an asymmetric disclosure regime (i.e., disclosure or nondisclosure). This result contrasts with the conventional wisdom obtained from a single Cournot market. This wisdom stems from the belief that firms prefer to avoid a more competitive market and concentrate their limited investment resources in a less competitive market, and multimarket contact allows firms to predict rival firms' behavior in Cournot competition.

Finally, several of our assumptions may raise concerns about the generalizability of our results. We assumed that multiple investments are perfect substitutes; one unit of one investment requires exactly one unit of another investment cost for simplicity. This narrows down the generalizability of our results and requires additional assumptions concerning investments substitutability. Again, we assumed that the disclosure regime in each market is based on the situation whether disclosed or not. This may exclude several issues for information disclosure, such as the extent of information requirements, disclosure of aggregated information, and alternative information. These concerns reveal several possible extensions for unveiling firms' behavior in multimarket competition in accounting research.

Appendix

Proof of Proposition 1.

Differentiating Eq. (6) for firm i's maximization problem at Stage 1 with respect to e_{Ai} and e_{Bi} yields a reaction function for each market as follows:

$$e_{Ai} = \frac{4\theta(a-c) - 4\theta e_{Aj} - 9e_{Bi}}{9-8\theta}, \tag{A.1}$$

$$e_{Bi} = \frac{4\theta(b-c) - 4\theta e_{Bj} - 9e_{Ai}}{9-8\theta}. \tag{A.2}$$

Solving the above equations simultaneously, we can obtain equilibrium investment levels e_{Ai}^{DD} and e_{Bi}^{DD}, which leads to results in Proposition 1.

Again, we can show how equilibrium investment levels in both disclosure markets respond to relevant market demand or other market demand as follows:

$$\frac{\partial e_{Ai}^{DD}(e_{Bi}^{DD})}{\partial a(b)} = -\frac{9-4\theta}{18-4\theta}, \tag{A.3}$$

$$\frac{\partial e_{Ai}^{DD}(e_{Bi}^{DD})}{\partial b(a)} = \frac{9}{18-4\theta}. \tag{A.4}$$

Proof of Proposition 2.

Differentiating Eq. (13) for firm i's maximization problem at Stage 1 with respect to e_{Ai} and e_{Bi} yields a reaction function for each market as follows:

$$e_{Ai} = \frac{2\theta(a-c) + \theta\hat{e}_{Ai} - 2\theta\hat{e}_{Aj} - 6e_{Bi}}{3(2-\theta)}, \tag{A.5}$$

$$e_{Bi} = \frac{2\theta(b-c) + \theta\hat{e}_{Bi} - 2\theta\hat{e}_{Bj} - 6e_{Ai}}{3(2-\theta)}. \tag{A.6}$$

Our assumption that all conjectures are formed rationally and will be sustained in equilibrium without revising conjectures allows us to replace $\hat{e}_{Ai} = e_{Ai}$, $\hat{e}_{Bi} = e_{Bi}$, $\hat{e}_{Aj} = e_{Aj}$ and $\hat{e}_{Bj} = e_{Bj}$. Solving four replaced reaction functions simultaneously, we can obtain equilibrium investment levels, e_{Ai}^{NN} and e_{Bi}^{NN}, which leads to the results in Proposition 2.

Again, we show how equilibrium investment levels in both nondisclosure markets respond to relevant market demand or other market demand as follows:

$$\frac{\partial e_{Ai}^{NN}(e_{Bi}^{NN})}{\partial a(b)} = -\frac{3-\theta}{6-\theta}, \tag{A.7}$$

$$\frac{\partial e_{Ai}^{NN}(e_{Bi}^{NN})}{\partial b(a)} = \frac{3}{6-\theta}. \tag{A.8}$$

Proof of Proposition 3.

In an asymmetric case, the reaction function in a disclosure market A is consistent with (A.1), and the reaction function in a nondisclosure market is consistent with (A.6). Similarly, we can replace $\hat{e}_{Bi} = e_{Bi}$ and $\hat{e}_{Bj} = e_{Bj}$ and obtain equilibrium investment levels e_{Ai}^{DN} and e_{Bi}^{DN} by solving four reaction functions simultaneously. This leads to the results in Proposition 3.

Again, we can show how equilibrium investment levels in asymmetric markets respond to relevant market demand or other market demand as follows:

$$\frac{\partial e_{Ai}^{DN}(e_{Bi}^{ND})}{\partial a(b)} = -\frac{12-4\theta}{21-4\theta}, \tag{A.9}$$

$$\frac{\partial e_{Ai}^{DN}(e_{Bi}^{ND})}{\partial b(a)} = \frac{8}{21-4\theta}. \tag{A.10}$$

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